



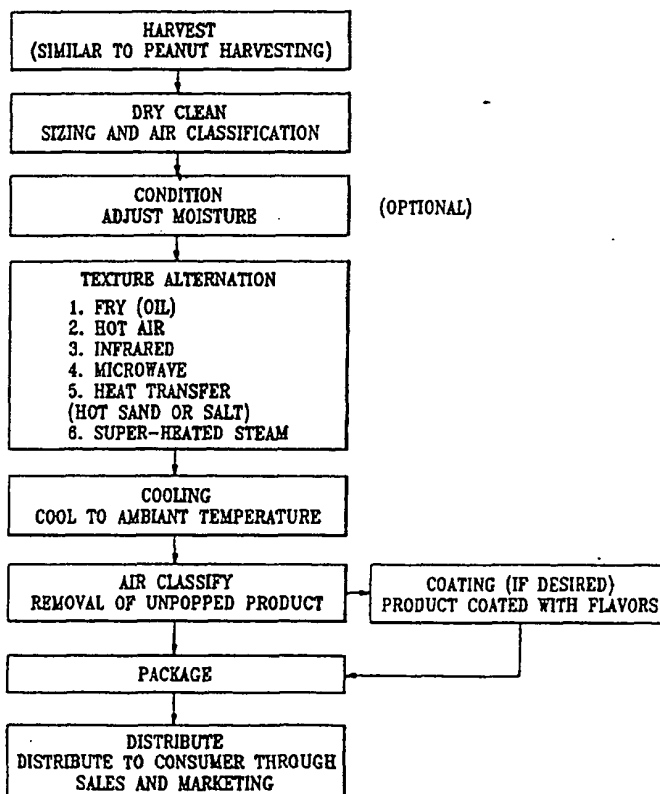
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(54) Title: POPPING BAMBARRA GROUNDNUT

(57) Abstract

The invention contemplates novel foodstuffs containing processed Bambarra groundnuts and methods for producing the same. Also described are conditioning methods for seed that impart a suitable moisture content to the seed such that the seed is endowed with the ability to pop upon the rapid application of heat.



DESCRIPTION

Popping Bambarra Groundnut

Related Applications

This application claims priority to Ehlers et al., POPPING BAMBARRA
5 GROUNDNUT, United States Provisional Patent Application No. 60/109,186 filed
November 20, 1998, hereby incorporated by reference in its entirety including drawings.

Field Of The Invention

This invention relates to novel processed foodstuffs derived from the Bambarra
groundnut (*Vigna subterranea*), an African grain legume virtually unknown in the United
10 States, and to methods and conditioning steps for preparing the same.

Background Of The Invention

Increased consumption of grain legumes in the United States and other developed
countries is widely considered to be a healthy goal by nutritionists as they are naturally
low in fat, and high in dietary fiber, protein, folic acid, and other nutrients. Consumption
15 of a wider diversity of food crops in general and grain legumes in particular is also
desirable. The limited types and the forms that grain legumes are offered to consumers is
one constraint to increased consumption. Utilization of "new" or under-exploited grain
legumes, such as the Bambarra groundnut, would therefore be useful but is hampered by a
lack of knowledge of how to utilize them in forms widely accepted by consumers,
20 especially in convenience or food snacks.

Bambarra groundnuts are grown by small scale farmers in the drier parts of tropical
Africa. The plant is similar in appearance to peanut (*Arachis hypogea*) in growth and
fruiting pattern, but distinct from peanut in origin, nutritional content and physical
properties of its seeds. Like peanut, the Bambarra groundnut plant produces small flowers
25 above-ground which, following pollination, curve toward the ground to bury the young
fruits at the base of the plant. Uguru, M.I. et al., J. Sci. Food Agric. (1997) 73, 377-382.
At maturity, the seeds are enclosed in a fibrous "shell" similar to that of peanut. Unlike
peanuts, however, which evolved in South America, Bambarra groundnuts evolved in
Africa. Another significant difference between the two is that Bambarra groundnut seeds
30 contain about 6% oil at maturity as compared to about 40% for peanuts. See Enwere, N.J.
et al., International Journal of Food Science and Nutrition (1996) 47, 469-475.
Consequently, Bambarra groundnuts are harder and drier than peanuts and require a

different processing to render them edible. They are also healthier and potentially avert the allergy problems commonly associated with peanuts and other nuts. Moreover, Bambarra cultivars have been identified that are productive in the U.S.

Traditional methods of use and preparation of this unique legume are limited to
5 boiling of immature fruits for direct consumption, boiling of mature fruits followed by mashing and flavoring, and pounding toasted mature fruits into flour for use in a variety of dishes. None of these methods of preparing Bambarra results in the unique, expanded, light, soft and pleasant tasting product of the instant invention.

Summary Of The Invention

10 The Applicant has observed that Bambarra groundnuts (*Vigna subterranea*) can be "popped" like popcorn thereby taking on a unique, healthy, and palatable consistency heretofore unknown. The popped product resembles roasted peanuts in texture and flavor, but is significantly less fatty and caloric. Moreover, stringent regulatory guidelines exist for peanut production and sales in the US, which do not apply to Bambarra.
15 Consequently, a relatively high production premium is exacted for peanuts and avoided by use of Bambarra. Hence, Bambarra potentially bodes large for the food industry as a relatively healthy, tasty and affordable foodstuff.

Processing of Bambarra seed, which is otherwise hard and inedible, into edible and healthy foodstuffs is an object of this invention and is accomplished using rapid heating
20 means such as hot air, oil, microwave, infrared, superheated steam, or hot particulate matter such as salt or sand. These rapid heating means can effectively "pop" the seeds of the Bambarra groundnut to achieve a palatable texture and taste uncharacteristic of the starting product. However, not all Bambarra groundnut cultivars are equally susceptible or amenable to popping. Nevertheless, Applicants have succeeded in converting otherwise
25 unamenable cultivars into popping cultivars via a seed-conditioning step preceding the rapid application of heat.

In terms of the conditioning step, the Applicant has noted that starting seed moisture content appears critical to the success of the popping phenomenon but can vary according to the exact heating method employed and possibly also to exact cultivar
30 identity and conditioning, if any. Seeds having an upper threshold moisture content of about 15% and greater do not substantially pop, whereas seeds having lower moisture contents, preferably 7-12%, pop well. However, rapid heating means employing oil exact a somewhat lesser requirement, i.e. permit a higher starting moisture content that still allows for good popping.

By "pop" is meant expansion or puffing of the grain and significant softening in texture following rapid heating. Prior to popping, the grain is so hard as to be virtually inedible while the popped product is relatively soft with a "chalky" texture that resembles toasted edible soybean or peanuts. Popping may also denote an audible noise associated with the phenomenon and/or a flavor conversion.

There are primarily two components of the instant invention that make it work: selection or conditioning of Bambarra grains to have a suitable grain moisture content at the time of "popping," and the rapid application of sufficient heat for sufficient time to induce popping. These parameters will vary depending on, for example, the precise Bambarra cultivar used, the atmospheric conditions in which the seeds are grown or exposed, the conditioning method employed, if any, and the specific means of heating employed. Suitable variance of these parameters, however, is well within the skilled artisan's knowledge and abilities.

Optimum and preferred aspects of the invention include products generated from and processes entailing the popping of raw or preconditioned Bambarra grain having a suitable or conditionable grain moisture content of preferably between about 5-15% (w-w), more preferably about 7-12%, and which yields the desired product when exposed to rapid and suitable heat or energy transfer. Use of oil heating allows the moisture content to be greater, up to about 14+%. Hot air, oil, particulate matter and superheated steam popping are all generally achieved using temperatures between about 110 and 250°C (~230-500°F), for approximately 1-10 minutes, depending on the specific method used. Hot air of about 140-180°C takes about 1-2 minutes. Oil frying generally requires less time (~30-60 seconds) and microwave cooking may require ~2-4 minutes, depending on the exact microwave unit used. Particulate matter cooking, depending on how fine the particulate matter is and temperature, may approximate oil in terms of time necessary to pop and likely is intermediate between hot air and oil. Coarser matter is likely to take longer than fine matter at the same temperature. The skilled artisan knows that cooking time can vary to accommodate the factors mentioned. Routine experimentation may be employed to conveniently map optimal parameters.

Brief Description of the Drawings

The following are intended as illustrative only, and not limiting.

Figure 1: A flowchart depicting a general popping process for Bambarra.

Figure 2: A flowchart depicting a specific and preferred process of popping Bambarra.

Various other embodiments and particulars will be apparent from the detailed description and claims that follow.

Detailed Description

5 All references and patents cited herein are hereby incorporated by reference in their entireties, word-for-word, drawing-for-drawing, and are not intended to be admitted prior art. Moreover, the examples and discussion herein are merely illustrative of the nature of the invention and not intended to be limiting as to true scope and spirit.

Definitions

10 By "snack food" is meant edible material— that is, material that is capable of being chewed and consumed as a matter of convenience. The term is subsumed into the broader term "foodstuffs", which connotes a more complex, highly processed food, or one that is used more as a staple food than as a fast, sporadic, snack food.

15 By "pop" or "popped" is meant the expansion or puffing of the grain and softening in texture. Prior to popping, the grain is so hard as to be virtually inedible, while the popped product is relatively soft with a "chalky" texture that resembles toasted edible soybean or peanuts. Popping may or may not connote an audible effect associated with the phenomenon and/or a flavor conversion. Popping is not the same as boiling, drying, baking, or soaking the grain. The resulting popped grain is distinguishable from grain which has not been treated by popping, based on properties such as density, moisture
20 content, and texture. The moisture content of popped Bambarra is less than 30%, preferably less than 15%.

By "texture" is meant primarily hardness and compression force characteristics necessary to crush or deform a foodstuff. Such may also connote a granular as opposed to a homogeneous soft consistency in the food, and various forms in between. In terms of
25 "popping," density is also lessened and therefore a function of texture. The texture of popped Bambarra is relatively soft with a "chalky" texture that resembles toasted edible soybean or peanuts.

By "suitable heat energy" is meant one that contributes or effectuates popping as described above. Preferably, it also connotes a temporal and temperature sufficiency such
30 that the kernels are substantially unburned and noncharred at the conclusion of popping. As known in the art, higher temperatures or higher energy wavelengths will require less time to cook/pop and vice-versa.

By "grain moisture content" or "seed moisture content" is meant roughly the amount of water inside the seed that can modulated, for example, by hydration or drying

of the seeds, or other manipulation. Such manipulations can also be coordinated with artificial flavoring steps.

By "peanut-substitute" is meant a foodstuff product with similar taste, texture and/or otherwise consistency of peanuts. This may or may not be a consequence of artificial flavoring additives or enhancements as known in the food arts.

By "processed" is meant converting from a raw form to a man-made one, such as in harvesting, which concentrates produce. The term can also connote conversion of a substantially inedible foodstuff to a substantially edible one, for example, by cooking or popping Bambarra groundnut.

By "conditioning" is meant a hydration and/or dehydration/drying step(s) to achieve a suitable starting moisture content as defined herein that enables popping. In addition to rendering Bambarra seeds more susceptible of popping or enabling popping altogether, the procedure may also be coupled with artificial flavor addition(s).

By "palatable" is meant edible, preferably desirable in taste.

By "particulate matter" is meant granular heat-sinking objects, such as sand or salt, that when heated and mixed with unpopped seeds conveys heat energy to effect popping of said seeds. Preferably such particulate matter is conveniently separable from the popped product.

As previously described, the Applicant has discovered that Bambarra groundnuts (*Vigna subterranea*) can be "popped" to thereby take on a unique, healthy, and palatable consistency heretofore unknown. This bodes large for the food industry, as the resultant products, if anything, resemble the texture, flavor and consistency of roasted peanuts, only healthier in fat, caloric content, and cost to the producer (and hence consumer).

The invention concerns the processing of otherwise inedible Bambarra groundnut seeds into edible and healthy foodstuffs using rapid heating means such as hot air, oil, microwaves, infrared waves, superheated steam, or hot particulate matter such as sand or salt to effectively "pop" Bambarra groundnut seed. Some Bambarra cultivars are more amenable to popping than others. Applicants have found that those cultivars that are not initially suitable can be converted to such using a conditioning step that establishes a suitable moisture content for popping. The Applicant has noted that moisture content correlates with popping ability. Thus, by manipulating moisture content, one can manipulate popping ability.

Hot air

Hot air popping is described, for example, in U.S. Patents 4,152,974, and 5,421,253. This method of popping has been referred to as "dry" popping and utilizes a stream of hot air as the popping medium. It has a number of advantages over wet popping.

5 For example, the additional calories and expense associated with oil popping are avoided. Moreover, various commercially available apparatuses use the stream of air to agitate the seeds and prevent non-uniform heating and popping. Thus, the procedure is relatively efficient in terms of converted, popped product. Corn kernels can be cooked using hot air of about 110-250°C (~230-500°F). Bambarra seed can likely be popped using similar

10 temperature parameters. The Applicants have had success using temperatures 110-180°C.

Hot oil

Hot oil popping is described, for example, in U.S. Patents 5,694,830 and 5,409,729. The oils and fats used should be edible, preferably from plant sources having polyunsaturated compositions that are considered healthier and lighter, for example, olive

15 oil, corn oil, sesame seed oil, soybean oil, sunflower oil, peanut oil, etc. Soybean oil is considered to impart a preferable "buttery" flavor to popcorn and may impart a characteristic to popped Bambarra seeds. The temperature used to pop the substrate can vary depending on the type of oil used, but generally the range 150-205°C is suitable, with temperatures in the range of about 180-190°C considered optimal. The degree of

20 individual seed pop (expansion size) generally varies proportionately with temperature; increasing temperature correlates with better expansion. Popcorn typically takes 2-5 minutes to pop. The Applicant has noticed that Bambarra seeds typically take less time. The preferred amount of oil to be used is about 1-30:1 oil:seed (w-w), with higher ratios being preferred. There is no apparent upper limit to the amount of oil that can be used but

25 economics dictate using the specified range.

Infra-red

Infra-red popping is described, for example, in U.S. Patent 5,478,986. Infrared radiation is of a higher wavelength and hence lower energy level than microwaves. The wavelength borders visible and near visible wavelength spectra and filters are available to

30 select for specific desired wavelengths emanating from a source. This method of popping has the advantage in that high intensity use of these longer wavelengths allow a lesser penetration that cooks predominantly just the husk of the seed, leaving the interior alone. This has the effect of focusing the cooking energy and accelerating the popping process. The technique may take as little as 15 seconds. Additionally, there is minimal burn on the

popped product, as it is predominantly the inner, starchy layers that are exposed upon popping and these layers are white and reflect light, thereby minimizing continued cooking of the fleshy interior of the seed. This method is also relatively energy efficient in that the walls of typical hardware units reflect light and therefore economize administered energy.

A typical unit contains quartz-halogen tungsten lamps, or equivalent means such as quartz arc lamps. Typical quartz-halogen lamps of this type convert electrical to black body radiant energy having a range of wavelengths from 0.4 μ m with a peak intensity at 0.965 μ m. These lamps can generally provide from 1-2 kW of radiant energy with a significant portion of the energy in the visible light spectrum. It is easier to configure larger infrared devices having multiple lamps than it is microwave ovens. Therefore, from a bulk commercial standpoint, this method offers a distinct advantage. Typical ovens can use one to as many as ten or more lamps operated in unison.

Microwave

Microwave popping is described, for example, in U.S. Patents 5,743,174, 4,450,180, 4,548,826, 4,691,374, 5,044,777, and 4,724,290. Microwaves are a form of electrical energy that are similar to radio and infrared waves. Domestic microwave units emit a frequency of about 2450 megahertz, which is the frequency reserved for industrial, scientific, and medical uses of the shorter radio waves. This corresponds to a wavelength of approximately 12 centimeters. Commercial supply of microwaves is abundant. Full size microwaves (larger than 1.2 cu. ft.) are available from 650-1,000 watts; intermediates: 600-800 watts; compacts: 500-700 watts. Most microwave instruction times on packages and in recipes are based on a 600-watt oven. A higher wattage unit heats more quickly; a lower wattage unit cooks more slowly. One of ordinary skill in the art can manipulate the time sufficient to pop Bambarra accordingly.

Steam

Steam popping or roasting is described, for example, in U.S. Patent 5,681,607. The subject patent describes a process for roasting coffee nuts that Applicant believes will also accommodate practice of the instant invention, with certain modifications understood to those of skill in the art. For example, popping borrowing this method will utilize a pressure and temperature controlled vesicle with a means for injecting superheated steam of between about 150 and 400°C, for about 50-300 seconds, at a pressure of between about 6.5-20.0 bars G. This is followed by a rapid pressure decrease and/or temperature drop that results in effective expansion (popping) of the seeds so exposed. This can be

accomplished, for example, by a rapid unsealing of the pressurized unit to equilibrate with atmospheric or sub-atmospheric pressure, and/or subjecting the vesicle's periphery to cooling water so as to effectively lessen the internal pressure. The United States Patents referenced in the section governing starch, below, are also helpful.

5 Applicant has found that suitable Bambarra popping parameters according to the preceding are, or are likely, attained without appreciable experimentation even though Bambarra has a distinct constitution, appeal and likely set of cooking parameters.

10 There are primarily two components to the instant invention: selection or conditioning of Bambarra cultivars to have a suitable grain moisture content for "popping," and application of a heating means at temperature and time sufficient to effect popping. These parameters, as discussed above, will vary depending, for example, on the precise Bambarra cultivar used and the specific means of heating applied. Effective variance and optimization of these parameters, however, is well within the skilled artisan's knowledge and abilities.

15 As also described, popping is denoted by a texture alteration of the cooked grain manifest as an expansion (shape/volume transmutation), coupled with a concomitant softening and lessening of grain density. The process also typically results in the loss of moisture from the seeds such that, initially and prior to processing, the seeds have a defined moisture content or range of moisture content that is lessened on popping. This
20 loss of moisture is usually manifest by the give-off of steam energy and hence water weight.

Selection of cultivars

Only a limited number of unconditioned germplasm accessions of Bambarra groundnut have thus far been evaluated for their ability to "pop" without prior
25 conditioning. A range in popping characteristics has been observed. Cultivars PI244969 and PI245952, for example, have exhibited good popping characteristics, while cultivars PI 244971 and PI 244972, by comparison, do not pop or expand only slightly after heating. All that is needed to conveniently evaluate new, untested cultivars for popping ability is a standard popcorn popper or heat source as described herein. Results are
30 obtainable within typically 10 minutes or less. The USDA-ARS makes publicly available each of the above cultivars and approximately 100 additional others that can be tested and potentially used according to the processes described herein. See http://www.ars-grin.gov/cgi-bin/npgs/html/acc_search.pl?accid=Vigna+subterranea).

Conditioning and theory

Those cultivars that are innately recalcitrant to popping or otherwise yield sub-optimum popping may be artificially, ie. chemically or physically treated to yield a suitable starting product that will pop. The easiest way to achieve suitable moisture is to simply dry (dehydrate) the seed to the appropriate moisture range. The Applicant has found it convenient to first hydrate and then dehydrate, for example, by immersing in water for a sufficient period of time, followed by slow drying to an appropriate moisture content. The hydration step may be facilitated by the use of a pressure-cooker or humidifier that allows for the accelerated upward adjustment of moisture. Commercial drying machines are available that permit controlled temperature and humidity drying. (Proctor & Schwartz Inc., Horsham, Pa., USA). Those of skill in the art are aware of equivalents. The drying should be slow as not to fracture the seed coat; fracture of the seed coat eliminates or minimizes the potential for desired popping.

Additionally, and to the extent non-popping dispositions are attributable to particularly strong seed coats, such coats might be weakened by chemical and/or mechanical treatment that falls short of fracturing the seed coat. Such treatment should preferably not involve caustic chemicals that are harmful when ingested. A cleansing or washing step should therefore be incorporated to insure chemical clearance. Preferably, conforming cultivars are selected to begin with, or else conditioned without the use of caustic or toxic chemicals. However, it is possible that some nonconforming cultivars possess other unique and desirable characteristics, for example, yield, ease of growth, superior nutrition, etc. for which such processes may then be used to render conformity. Plant breeding is another possibility for overcoming obstacles. By selecting and propagating desirable traits, one can produce new plants bearing new traits and combinations of traits.

As discussed above, the Applicant has evaluated and determined that moisture content has a strong correlation with popping success. For example, at moisture contents of about 15% or more, no or minimal popping is observed. The groundnuts fail to expand. Instead, they take on a darkened, hard exterior. At moisture contents of about 12% or less, however, popping occurs. The Applicants hypothesized that expansion (popping) of a seed having preferable moisture contents, as discussed, might be the product of rapid vaporization pressures within the seed that quickly overcome the seed shell structural fortification. Higher moisture contents likely take longer to heat, thereby resulting in an equilibration across the seed coat instead of a rupturing steam energy differential. Applicants believe they have confirmed this, but nevertheless do not wish to represent this theory as necessarily correct or limiting.

Applicants as well as others have also noted and implicated starch properties in popping success. See, e.g., U.S. Patents 3,652,294, 3,800,050, 4,990,348, 4,409,250 and 5,320,858. For example, the author has noted that par-boiling rice to effectively pre-gelatinize the starch within, coupled with a subsequent cooling step under controlled pressure and humidity, results in a later effective "popping" of the rice on rapid heating. Starch is a common product in flour, and a significant component of grain endosperm. While Bambarra groundnut is not a monocot grain in the classic sense, its seed nevertheless possesses starch that can and may be gelatinized in the conditioning and/or popping process. Consistent with popping ability, those cultivars of Bambarra that pop without conditioning have a starch content of ~50-65% and a moisture content as previously noted.

Preferred aspects and embodiments

Optimum and preferred aspects of the invention include products generated from and processes entailing the popping of raw or preconditioned Bambarra grain having a suitable predetermined or preconditioned grain moisture content of preferably between about 5-15%, more preferably about 7-12%, that when exposed to temperatures of between about 110-250°C, preferably about 150-180°C, for approximately 1-10 minutes, more preferably about 1-5 minutes, and most preferably about 1-4 minutes, depending on the exact method used, yields the desired product. Other temperature ranges and time spans may be determined to be appropriate depending on the heating technique employed, the exact starting product, and other environmental conditions. The Applicant has delineated particulars in the examples below that worked best for Applicant as of this filing. The Applicant does not wish these particulars to be limiting, especially in recognition that more suitable parameters may ultimately be identified. The Applicant considers the broad temperature ranges listed herein, apart from the examples, to likely suffice, all factors considered. The goal is to effect popping, preferably without otherwise burning or charring the seeds.

Once popped, the Bambarra seeds may be artificially or naturally cooled as part of an integrated, commercial processing procedure. Preferably the procedure does not allow the resulting popped product to accumulate moisture. Optionally, the popped seeds are also culled of unpopped kernels by, for example, an air classifying scheme that is common within the food-processing industry and known to those of skill in the art. (See, e.g., popcorn instrumentation available commercially from C. Cretors and Co. (Chicago, Ill.)).

Integrated into the process may also be a flavoring step wherein the popped seeds are coated with any one or a combination of commercially available flavorings, preferably

nonallergenic, artificial nut flavorings such as peanut, cashew, hazelnut or walnut. Mixtures bearing different flavors are also contemplated. The flavorings need not be nut and may, alternatively or in combination, be selected from generic or specialized sweeteners, salts, butter or other butter substitutes, spices, and other flavor embellishers such as caramel or cheese.

Flavoring may occur before, after, or during popping, for example, according to the procedures as described in U.S. Patents 5,688,543, 5,443,858, and 5,750,166, and 5,753,287. Other procedures are also possible and within the skill of one skilled in the art. Those in the food industry, for example, will see a great range of potential for flavoring of popped and unpopped Bambarra. Preferably, but not essentially, the flavoring additions will minimize introduced calories, thereby preserving the innate healthy nature of the Bambarra seeds relative to peanuts, cashews, and other processed foods.

Preferred embodiments include popped Bambarra seeds that are optionally flavored and packaged as a snack food or crouton-like salad supplement. Other product formulations and configurations, ie. candy or health bars are also contemplated. The possibilities are broad.

To this end and others, certain processing and product embodiments may also incorporate mixtures of popped Bambara seeds and other components such as raw or dried fruits, fruit juices, seeds, and nuts. Various product configurations may be held together by, for example, honey, caramel or molasses and contain, for example, raw sugar, raisins, dates and/or figs. Chocolate may be added in less health-conscious embodiments.

Once the Bambarra product has been configured as desired, a terminal step in the food manufacturing process is packaging—something well known in the art. This packaging may occur before or after popping. For the former, unpopped seeds are supplied in microwaveable bags like exist for popcorn, and that are commercialized with directions for cooking. U.S. patents 5,770,839, 5,488,220, and 5,681,607 describe such bags in detail. Alternatively, the unpopped seeds may be supplied in jars or other containers from which a set number of seeds can be dispensed and cooked/popped according to directions supplied therewith and corresponding to methods included herein.

Another and particularly attractive embodiment of the processed nut is as a blended, homogenized spread that has a consistency and/or taste like peanut butter. To this end, the Applicants have applied for a federally registered trademark for the name Beanut Butter™. The mark Bean Nuts® has already been acquired for processed nuts, generally.

A homogenized buttery blend may be achieved using methods well known in the food arts, e.g., by creating a paste out of the popped nuts using, e.g., a commercial

grinding apparatus such as a comminuter, colloid mill, hammermill, attrition mill, or other disintegrating device. This paste may have to be supplemented with other oils if the innate oil within the popped nuts is insufficient, or to otherwise vary consistency of the finished product. Additives such as stabilizing agents, emulsifying agents, salt, and/or sweetening agents may be further included, and is well known in the food arts. This is discussed in the peanut context, for example, in US Patents 5,240,734 issued to Izzo et al., 5,436,023 issued to Avera, 5,366,754 issued to Rudan et al., 5,714,193 issued to Fix et al., 5,948,954 issued to Horn et al., and 5,518,755 issued to Wong et al. Those patents and all others cited in this patent application are hereby incorporated by reference.

Various examples to follow highlight and illustrate the essential underlying conditioning and popping processes, means, and the unique resulting Bambarra products and product configurations. Those of skill in the art will know how to pursue the various aforementioned embodiments. Those embodiments, as well as the examples that follow, are intended merely to illustrate the possibilities and are not intended to limit the true scope and spirit of the invention.

Examples

Example 1: Popping Bambarra seeds using hot air.

Suitable cultivars or test cultivars were obtained as described above. The husks, which are peanut-like were first removed, thereby exposing the hard, substantially inedible seed to be popped. The seeds were then pooled into a hot air popcorn-type popper, e.g., Presto®(small-scale) or Cretor's®(large, industrial scale) and cooked roughly following the manufacturer's guidelines for popcorn. This corresponded to approximately 1-2 minutes of exposure time at about 150-180°C (~300-356°F).

Example 2: Popping Bambarra seeds using a microwave oven.

This was performed substantially as in example 1, except that the seeds were positioned on a glass plate within a 1000W microwave oven and cooked on a regular setting for 2-4 minutes, periodically gauging the extent of pop. This can vary for various standard home units, as described above.

Example 3: Popping Bambarra seeds using hot oil.

Seeds were overlayed over a thin layer of cooking oil in an encapsulated vessel and a heating element source was supplied to heat the oil to between about 165-170°C (~330-340°F) to pop the seeds contained within the vessel. The vessel served to contain volume

and pressure so that the heating was performed rapidly and efficiently. The Applicant has observed that seed moisture content may be elevated approximately 1-2% and still be successful using this method relative to those methods employing hot air, etc. Also, frying in oil was observed to take less time than the other methods, ~30 seconds- 1 minute.

5 Example 4: Popping Bambarra seeds using particulate matter.

Dehulled seeds were mixed with finely particulate and preheated (~150-200°C) sand or salt in a vessel for approximately 30-60 seconds to effect popping. Unpopped seeds were then separated from popped seeds by a sieving scheme. The exact time of cooking depends on the identity and coarseness of the particulate matter used, as well as
10 temperature, etc. During this type, or any type of heating method, agitation can be useful to stimulate uniform heating and to prevent burning of the popped product.

Example 5: Conditioning the seed

Applicant has determined that, whereas a simple drying step may be sufficient to render a suitable moisture content for popping, a conditioning method that employs a
15 hydration step works in the event that mere drying is insufficient. For example, a poor-popping Bambarra seed, e.g, cultivar PI 244972, was positioned into an open kettle having water at atmospheric condition and boiled for approximately 90 minutes such that the seed moisture content becomes approximately 50-60%, or else the seed was placed in a pressure steam cooker for approximately 45 minutes. Lesser hydrations may suffice. The
20 resultant seed was then slowly dried at approximately 80°C and 20% relative humidity until the seed moisture content was suitable for popping (less than 15%, and depending on the popping method used and other factors; 7-12% is generally effective for all methods). The seed was then popped according to any of the above methods, and popping efficiency found to be ~50% effective, whereas unconditioned seed of the same cultivar popped
25 significantly less. Further optimization and variation to suit a given situation is within the skilled artisan's routine understanding and abilities. Multiple rounds of conditioning, as described herein, may be useful in some applications. The Applicant verified that the general conditioning step described above also works for other cultivars. The exact parameters used above can likely be modified with similar success.

30 Example 6: Homogenized, blending spreads comprised of Bambarra nuts.

This prophetic example borrows from Examples 1 and 2 of US Patent 5,714,193 issued to Fix et al., and significant variations on the core concept are envisioned. The components are essentially the same as described in those examples except for a

substitution of popped nuts for peanuts in an amount ranging from about 60-83.9% weight of the total ingredients. Sugar comprises about 5.8%, oil content varies between about 6.45%-12% (to compensate for bean weight), salt represents about 1.2%, molasses about 0.5%, stabilizer (e.g., hardened rapeseed oil blended with hydrogenated soybean oil) about 5 1.85% and emulsifier (e.g., mono and diglycerides of palmitic and stearic acids) about 0.3%. The popped nuts are ground to a paste in a milling device and transferred to a mixing tank, to which is then added the other ingredients. The tank is held at a constant temperature of about 150 degrees F (~65.6 C), and the items are mixed therein for approximately 30 minutes, after which they may be further processed according to well 10 known art methods. The finished product may be marketed under the brand name Beanut Butter™.

Other embodiments are within the claims.

Claims

1. A foodstuff comprising popped seeds of the plant species *Vigna subterranea*.

2. The foodstuff of claim 1 wherein said popped seeds have a lower density
5 and higher volume on average than unpopped seeds of the same cultivar.

3. The foodstuff of claim 1 wherein said popped seeds have a softer texture than unpopped seeds.

4. The foodstuff of claim 1 wherein said seeds are popped by the rapid application of a suitable heat energy for a suitable time, said suitable heat energy selected
10 from the group consisting of hot air, hot oil, superheated steam, microwaves, infrared waves, and hot particulate matter.

5. The foodstuff of any of claims 1-3 wherein said seeds are popped by the application of hot air between about 110°C and 180°C for about 1-2 minutes.

6. The foodstuff of any of claims 1-4, wherein said seed has a grain moisture
15 content of about 7-12% prior to popping.

7. A peanut-substitute foodstuff comprising seeds of the plant species *Vigna subterranea*.

8. A process of preparing *Vigna subterranea* seeds for consumption, comprising the step of popping said seeds to induce a palatable texture alteration.

9. The process of claim 8 additionally comprising the step of optionally
20 conditioning said seeds to a suitable moisture content prior to said popping.

10. The process of claim 8 or 9 wherein said treating said seeds to induce a palatable texture alteration comprises administering a heat energy source selected from the group consisting of superheated steam, hot oil, hot air, microwave, infrared waves, and hot
25 particulate matter.

11. The process of claim 9 further comprising the step of removing unpopped seeds following said popping.

12. The process of claim 10 further comprising the step of flavoring said seeds.

13. A method of conditioning seeds such that said seeds pop when exposed to a rapid heating means, comprising:
5 optionally hydrating said seeds; and
drying said seeds such that said seeds achieve a suitable moisture content for popping.

14. The method of claim 13 wherein said hydrating is accomplished by boiling
10 said seeds.

15. The method of claim 13 wherein said hydrating is accomplished by exposing said seeds within a steam pressure-cooker.

16. The method of claim 13 wherein said hydrating infuses at least a 1.5-fold initial starting moisture content to the seeds.

17. The method of claim 13 wherein said suitable moisture content is less than
15 15%.

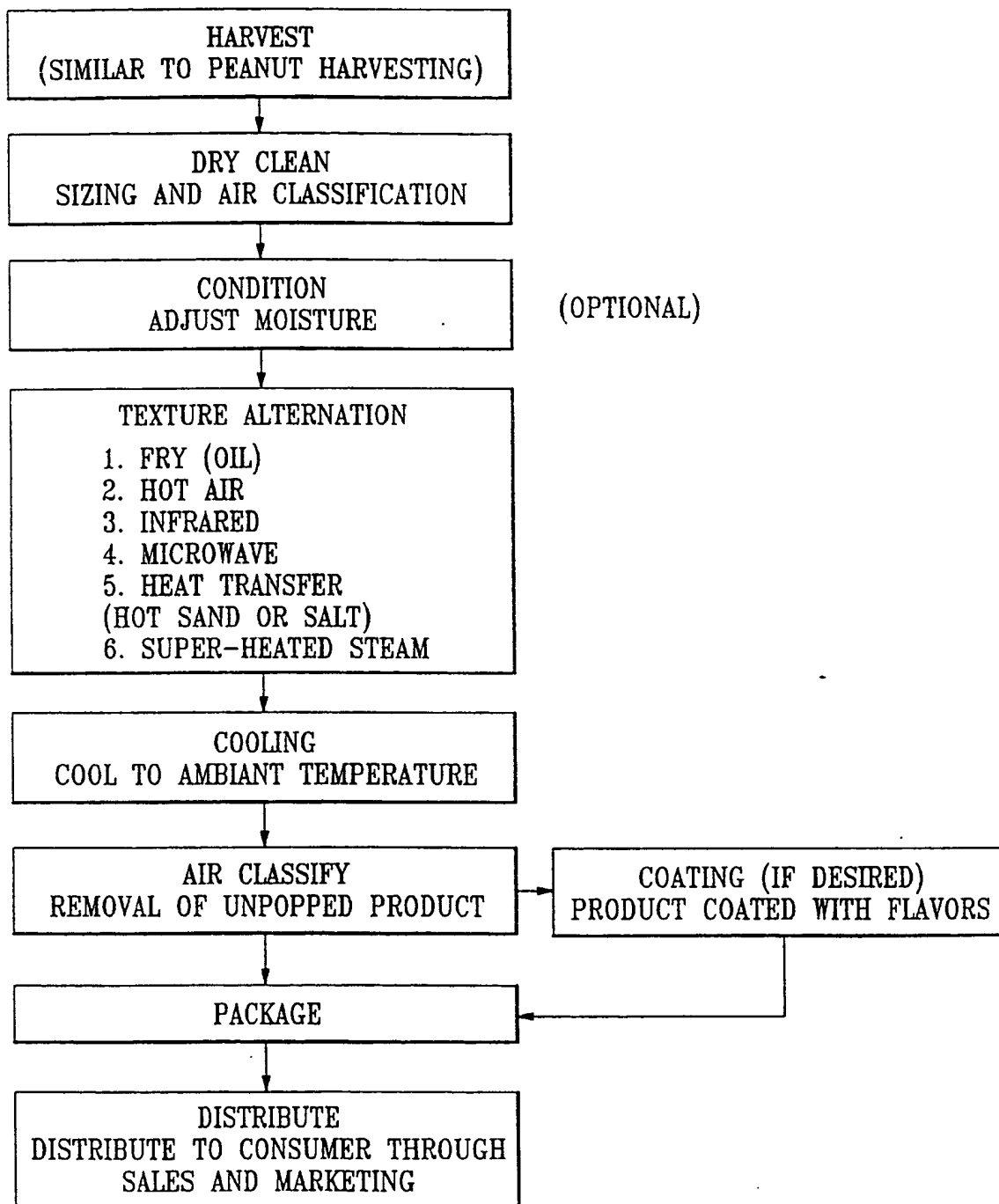
18. The method of claim 13 wherein said drying is in a controlled humidity environment.

19. The method of any of claims 12-17 wherein said seeds are from *Vigna*
20 *subterranea*.

20. The foodstuff of any of claims 1-7, wherein said foodstuff is a snack food.

21. The foodstuff or snack food of any of claims 1-7 and 20 wherein said foodstuff or snack food is a homogenized, blended spread.

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Fig. 1

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Fig. 2